

**Final Report to the
U.S. Environmental Protection Agency, Region 7**

**Assessing Urban Wetlands
(CD 99792501-0)**

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Abstract

This project was initiated to determine the impact of urbanization upon watersheds containing wetlands. The East Fork Little Blue River and the Rock Creek watersheds were chosen to assess the influence urbanization has had on the water and soil quality and plant diversity. Assessment of the amount of wetland acreage lost or gained since the National Wetland Inventory (NWI) was of critical importance for this project. Land use changes within each watershed were determined through interpretation of aerial photography. The East Fork watershed saw an increase of almost 40% of urban area and over 27% increase in wetland habitat. A significant portion of this escalation in wetland acreage is due to the construction of Blue Springs Lake. The Rock Creek watershed however, saw an 8.4% increase in urban land and a 6.5% decrease in wetland acreage.

Water quality was collected on a quarterly basis in both watersheds at sites selected using a stratified random sampling design. Eight parameters were analyzed: total phosphorous, pH, dissolved oxygen, conductivity, nitrate, nitrite, ammonia nitrate, and temperature. Results indicate that to date there has not been a detrimental effect to water quality within the wetlands sampled.

Soil was analyzed for copper, lead, zinc, and nickel at each wetland site in the spring of 2002. Results indicate that the levels of these metals are very minimal and well below concentrations found in other studies of urban areas.

A plant survey was also conducted at the sites chosen for water quality sampling. Scrutiny of plant inventory data highlights the variability of plant range from hydrophytic to upland locations within NWI designated wetland locations.

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The cooperation and support of the Jackson County Parks and Recreation Department as well as Mastodon State Historic Site has been greatly appreciated. By allowing me to conduct research on these public lands, a deeper understanding of urban wetlands has been attained.

I would also like to thank Jennifer Kamp for assisting me in this project. The numerous days of sweltering Missouri heat and humidity while collecting water samples and identifying plants were made easier with the help of another pair of eyes and helping hands.

Throughout the project I would occasionally consult with Clayton Blodgett, Missouri Resource Assessment Partnership (MoRAP), to harvest his knowledge and expertise in land use/land cover classification and aerial photo interpretation. His willingness and ability to educate has always been beyond expectation.

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Introduction

Missouri has already lost 87 percent of its wetlands, which exceeds the national average (Dahl 1990). With slightly more than 10 percent of Missouri's historical wetland areas still existing, it is paramount we focus our limited resources on activities that have the greatest impact on those wetlands that remain. Urban sprawl is one of the largest environmental concerns of our modern society. In many instances, due to the lack of coordination between agencies, an emphasis on economic development, or the lack of wetland knowledge among decision-makers and the public, sensitive and beneficial wetland ecosystems are adversely impacted.

Bernert et al (1999) postulates that urbanization accounts for the majority of wetland losses in urban areas. Storm water collects oil, chemicals, trash and other pollutants and delivers it to the local creeks. This impairs water quality and impacts the biodiversity of the creek, yet the affects of this influx to urban wetlands needs to be explored. Construction activities and alterations to the hydrologic regime also affect water input into wetlands and therefore may impact their function. These wetlands often suffer from invasive species, which colonize disturbed areas and displace native species. Many researchers and authors have commented that small, scattered wetlands within urban watersheds serve an important role in maintaining water quality, flood attenuation, and habitat functions. In fact, smaller urban wetlands may be more valuable than rural wetlands to their developed watersheds for water quality improvement and flood retention.

Missouri's policy-makers and permit reviewers currently have no base-line data on the extent of wetland loss in urban watersheds. The results of this study will begin to quantify the impact of urbanization on Missouri's wetland resources.

Study Areas

East Fork Little Blue River

The 85 square kilometer watershed of the East Fork Little Blue River lies in central Jackson County, Missouri (Figure 1). The river flows through three reservoirs at a gradient of 1.07 m/km for approximately 7.4 kilometers north/northeast until it joins the Little Blue River, a tributary to the Missouri River (U.S. Army Corps of Engineers 1991). The East Fork has had three dams constructed along its reach, the first lakes constructed were Lake Jacomo and Prairie Lee Lake in the early and mid-1950's; Blue Springs Lake was closed in 1986.

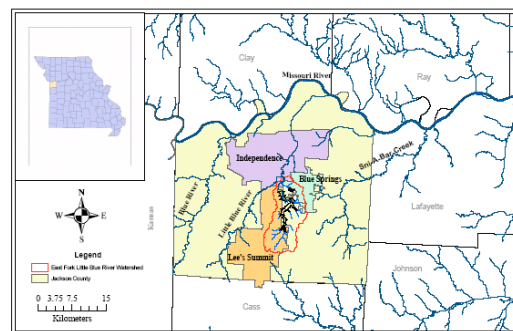


Figure 1. East Fork Little Blue River watershed.

The East Fork is part of the Jackson County Prairie/Woodland Scarped Plain that consists of rolling hills and scarped limestone valleys. The uplands consist of deep, silty soils that transition into limestone and shale residuum in the valleys (Nigh and Schroeder, 2002).

Historically, the predominant land use was farming in this humid temperate climate where annual precipitation averages approximately 86.36 centimeters and average temperature ranges from -4 °C in January to 25° C in July.

Within the last 20 years, urban growth from the Kansas City metropolitan area has spread into eastern Jackson County prompting significant commercial and residential development. Today, the cities of Lee's Summit and Blue Springs account for most of the growth within the East Fork Little Blue River Watershed.

Sampling was conducted at wetland sites near Lake Jacomo within Fleming Park (Figure 2). Four areas (D, E, F, and H) were chosen to represent the watershed.



Figure 2. Sampling locations in the East Fork Little Blue River watershed.

Rock Creek

The Rock Creek watershed (Figure 3) lies within the Meramec Highlands Oak Woodland/Forest Rugged Hills complex of eastern Missouri. This area is comprised of steep slopes and narrow valleys of sandstone and dolomite (Nigh and Schroeder, 2002). Few towns exist in this 77 square kilometer watershed, however many residential neighborhoods have been developed to accommodate the ever sprawling St. Louis population.

Since the 1990 census, the population in the watershed has increased 20%. Kimmswick and Imperial are the main towns in this watershed. Mastodon State Historic Site is where sampling was conducted (Figure 4).

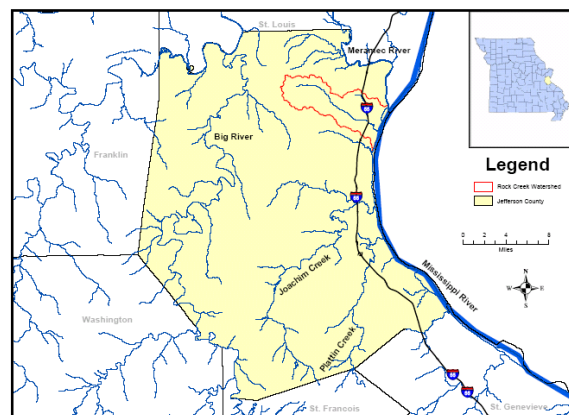


Figure 3. Rock Creek Watershed

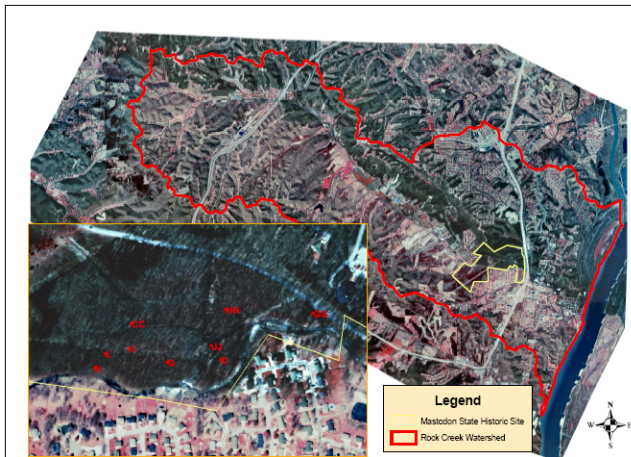


Figure 4. Sampling locations in the Rock Creek watershed.

Background

Wetland Mapping and Inventory

Examination of historical wetland losses within the United States prompted Congress to pass the Emergency Wetlands Resources Act (PL 99-645) in 1986. As a part of this act, the United States Fish and Wildlife Service (USFWS) is required to submit a report to Congress on the status and trends of wetlands every 10 years. Consequently, the National Wetland Inventory (NWI) initiated.

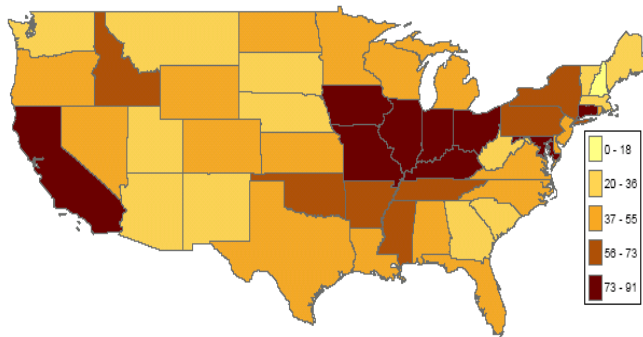


Figure 5. Wetland losses (shown as percentage) within the conterminous United States from the 1780's to the mid 1980's. From Dahl 1990.

In 1990, a preliminary report provided commentary on U.S. wetland losses between the 1780's and 1980's (Dahl 1990). The report summarized wetland acreage estimations from other studies, such as that of potential farmland (Roe and Ayers 1954) and mapping of hydric soil (U.S. Department of Agriculture, Soil

Survey Staff, 1975). Dahl discovered that there was significant wetland loss since the

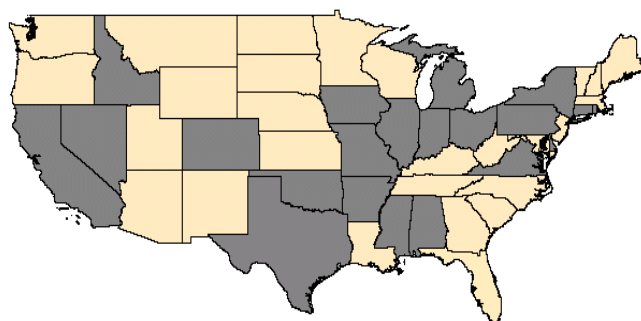


Figure 6. Wetland losses of 50% or more between the 1780's and mid-1980's. Hawaii and Alaska not included. From Dahl 1990.

1780's (Figure 5). The states having lost more than 50% of their wetlands were located in areas of agricultural activity underscoring the cause of most wetland conversions (Figure 6).

The USFWS utilized aerial photographic interpretation to establish wetland acreage for the first Status and Trends Report released in 1991. They used

1:58,000 scale color infrared aerial photographs and other regional and local maps to help

establish wetland areas for the years between the mid 1970's to the mid 1980's. Approximately 2.6 million acres of wetlands were lost during the ten-year study period with freshwater, forested wetlands sustaining the heaviest losses (Dahl 1991).

Wetland loss was much less from 1986 to 1997 (Dahl 2000). The USFWS estimated that a net loss of 644,000 acres of wetlands had been lost, compared to 2.6 million acres in the previous decade. Urban development and agriculture are among the leading causes of wetland removal in the United States (Dahl 2000). However, 180,000 acres of wetlands were either restored or created during this time period with the implementation of mitigation banking and an increase in the awareness of the benefits of wetlands.

Local and regional studies have supplemented the findings at the national level. In the Willamette Valley, Oregon, agriculture was responsible for 70% of the wetland loss between 1981/82 and 1994. Using larger scale data (1:20,000) by which to classify wetlands, Bernert et al (1999) discovered more wetlands than had been identified on the National Wetland Inventory, National Resource Inventory (NRI) or any other studies conducted in the Willamette Valley region.

Land conversion for agriculture and the logging industry was the main reason for a decline in forested wetlands in the Cache River Basin, Arkansas. Kress and Graves (1996) used Landsat Thematic Mapper (TM) satellite imagery and soils maps to identify forested wetland areas using a dataset from 1987. The TM data was compared against topographic maps from 1935 and 1975, which were digitized in a GIS. The removal of most forested wetlands occurred between 1935 and 1975. Kress and Graves also noted that the forested areas were more divided in the 1987 dataset than in either of the two other time periods. This fragmentation has lead to changes in sedimentation rates and hydrology within the basin.

Hydrologic and land use changes, which are considered as indirect impacts to wetlands, are just as detrimentally influential to wetland acreage as direct impacts (such as impoundment or conversion to open water). Cowan and Turner (1988) used aerial photography to assess the wetland habitat alteration from 1955/6 to 1978 in the coastal areas of Louisiana. They found that most wetland loss occurred in areas that were most affected by human modification either through construction of canals or other flood control structures.

Holland et al (1995) used manual evaluation of wetlands in the Portland, Oregon area to determine the effect of urbanization on small (≤ 2 ha) wetlands. Using the NWI as baseline data for their study, they selected wetlands from the NWI to visit in the field. Research showed that the closer a wetland resided to the urban growth boundary, the more likely it was to be impacted or removed. Climate may also have adversely impacted the wetland acreage as drought had controlled the area for seven years prior to the study.

Ecological Aspects of Wetlands

Wetlands have long been recognized for their diverse habitat and their ability to enhance water quality. Whether it is constructed wetlands for use in wastewater treatment plants

or natural wetlands that reduce sediment concentrations from urban and agricultural lands, wetlands are highly valuable features on the landscape (Mitsch and Gosselink 1993; Evans, Gilliam and Lilly 1996).

Even though wetlands are able to filter polluted water, there is a point at which the wetland itself becomes polluted. Wetlands in urbanized watersheds often become degraded due to excess nutrients (i.e. phosphorous and nitrogen) and/or sediment influx (Sorrano, Hubler and Carpenter 1996; Wear, Turner and Naiman 1998; Bowen and Valiela 2001; Loughheed, Crosbie and Chow-Fraser 2001). As wetlands are lost as a result of land use conversions or degraded by excess nutrients, biodiversity consequences arise. Gibbs (2000) found that palustrine wetlands are only able to sustain moderate alterations to their ecosystems before the biota is adversely affected.

Evidence of human induced pollution can be found by analyzing soils for metal concentrations. A study of several metals (cadmium, chromium, copper, magnesium, nickel, lead, selenium and zinc) at Indiana Dunes National Lakeshore revealed that concentrations were higher in sampled areas that were closest to the source. Furthermore, some metals (zinc and magnesium) were locally scattered by flooding and had the potential to effect numerous areas of wetland ecosystems (Perkins, Fillipelli and Souch 2000).

Connor and Thomas (2003) substantiate these findings because they found high concentrations of metals (cadmium, copper, iron, lead and zinc) in wetlands near old industrial sites in Australia. Core soil samples were analyzed to determine the historical concentration levels and found that most still exceeded modern levels of acceptance. Even though they sampled coastal wetlands, their study showed the retention capacity of wetlands for atmospheric pollution in soils.

Methods

Watershed Selection

Two watersheds were chosen using three parameters: urbanization, presence of wetlands and access to remaining wetlands. Ryan Burson, the Missouri State Demographer, was consulted to establish criteria of an urban area and to understand which areas within Missouri that would meet the classification. Once that was accomplished, the next selection criteria involved wetlands. For a watershed to be considered there must have been wetlands identified in twenty years ago on the National Wetland Inventory and wetlands that still exist today. Wetland areas were sought out by conferring with representatives from the U.S. Army Corps of Engineers, USDA/Natural Resource Conservation Service, U.S. Environmental Protection Agency, and the Missouri Department of Conservation. Finally, and most importantly, public land had to contain wetlands from which to sample water, soil and plants.

Location of Sampling Sites

The location of sampling sites was chosen using a stratified random sampling technique. For instance, among the wetlands at Mastodon State Historic Site, approximately 25

locations were identified for potential selection using a GPS, and then were assigned a designation (a, b, c, etc.). The latitude and longitude positions were then plotted in a GIS overlaying the NWI wetland boundaries to distinguish between wetland types. The potential locations were then classified according to wetland type (i.e. forested and scrub shrub) within MSHS. The list of sampling locations was narrowed to nine locations randomly. The same methodology was used when selecting sample sites near Lake Jacomo.

Site locations were originally marked with one-foot tall yard markers. It soon became apparent that taller, more obvious markers would be needed, especially in summer when the plants were thriving. Six-foot tall garden stakes were purchased along with orange spray paint, which was used to spray the tops of the stakes for easy viewing. A few stakes had to be replaced throughout the project term.

Water samples were collected, and plants were surveyed from each sampling site on a quarterly basis from March 2002 until January 2004. Soil samples were collected from the four East Fork Little Blue River study sites in March 2002. One soil sample was collected from the Rock Creek study site in June 2002. A 1.5square meter plot was used to collect water, soil and plant samples.

Land Use/Land Cover Change

The NWI was created by interpreting aerial photographs taken in April, 1984 and March, 1985 for the Rock Creek watershed, and October, 1981 and May, 1983 for the East Fork watershed. The photos were from the National High Altitude Program (NHAP), was 1:58,000 scale and utilized color-infrared. Copies of these photos are available for purchase from the United States Department of Agriculture's Aerial Photo Field Office (USDA/APFO) in Salt Lake City, Utah. The appropriate photos were obtained for each watershed in paper format and scanned at a resolution of 300 dots per inch. Once in a digital form, the photos were then georeferenced for use in a GIS. Land use/land cover was interpreted from the aerial photos using protocol from the Manual of Photographic Interpretation (Tiner 1997a). Other than wetland habitat, land use/land cover was classified using three broad categories: urban, agricultural, and forested land (Anderson 1976). The wetland habitat was categorized into System and Class, based on Cowardin et al (1979) as shown in Table 1 and Table 3. Once the entire watershed was classified, the acreage amount for each category was generated using the "X-Tools" utility available for ArcGIS users.

A comparison dataset was created from aerial photos obtained in March 2002 from Sanborn Mapping. This set of aerial photographs was also color infrared but at 1:10,000 scale. Photo interpretation was performed by the hydrologist using the same land use/land cover of wetlands, agriculture, urban and forested land. This allowed for determination of the loss, or gain, of wetlands as well as the three broad categories mentioned above.

While the NWI is the basis from which most wetland loss/gain calculations are made, there are certain limitations to that database and photographic interpretation in general. Tiner (1997b) lists fourteen examples of NWI map limitations, including mapping of

linear wetlands, farmed wetlands, forested or coastal wetlands and so on. These limitations are certainly noteworthy, however the NWI is intended only as a guide to potential wetland habitat and was not meant to replace ground surface wetland delineation conducted by those certified to do so.

Every effort was made to produce reliable maps. Photographs were taken in March during the leaf-off season, which aided in identifying forested wetlands. The film type used was color infrared, which enables a greater distinction between wetland and upland environments through analysis of image tone and color (Lillesand and Kiefer 2000).

Water Quality Sampling

Water samples were collected using 1000 ml cubitainers and processed according to EPA approved methods. Dissolved oxygen, conductivity, pH and temperature were measured using a Hach SensION 150 portable meter. Nitrate, nitrite, ammonia nitrate and total phosphorous were measured using a Hach DR 2000. Samples were collected on a quarterly basis when water was available. Results of the water quality tests were logged on a Field Data Sheet (Appendix A) and then transferred into a digital database once back in the office. The Hach meters were designed for temperatures 32°F and above. In the instances in which the temperature was below freezing, water samples were collected following MDNR Standard Operating Procedures (SOP), which are approved by the U.S. Environmental Protection Agency. Specifically, SOP#MDNR-FSS-005 for grab sample collection, SOP#MDNR-FSS-002 for Field Sheet and Chain-of-Custody Record and SOP#MDNR-FSS-003 for Sample Numbering and Labeling.

Soil Sampling

One composite soil sample was collected for each wetland site. Soil was analyzed for metals thought to be associated with urbanization: copper, nickel, lead, and zinc. Soil was collected from the top 0-2 inches using a stainless steel spoon and deposited into an aluminum pan. After all samples were collected, the soil was mixed and then used to fill a glass jar with a Teflon lined lid. The sample was then put on ice in a cooler and delivered to the Environmental Services Laboratory within 24 hours and documented with a Chain of Custody form. The Standard Operating Procedures are listed in Appendix A.

Plant Survey

Plants were identified to the species level on a quarterly basis within the same 1.5 square meter plot from which water and soil samples were collected. Extra trips were necessary in April and October when some wetland plants are blooming, making them easier to identify. A list of plants identified is included in Appendix A.

Results

Land Use/Land Cover Change

East Fork Little Blue River

The increase in urban land was mainly at the expense of forested land and agriculture (Table 1). The 28% increase in wetland habitat is a deceptive statistic. Significant amounts of palustrine, forested wetlands were inundated and therefore lost when Blue

Springs Lake was created. In their place, one large lacustrine system was formed. This type of wetland conversion is deleterious. As other studies have suggested when analyzing mitigation sites, the resulting lacustrine habitat is very different from the former. Therefore, it should not be considered the same in terms of functions and values (Turner, Redmond and Zedler 2001).



Figure 7. Land use change is evident since the NWI (green) was created for the East Fork watershed. Wetlands identified in 2002 are indicated in yellow.

LU/LC Category	1984/5	2002	Change
Urban	11,085	18,460	+40%
Wetlands	1,612	2,225	+28%
Forest	3,167	1,739	-45%
Agriculture	9,702	3,148	-68%
Total	25,566	25,572	

Table 1. Land use/land cover changes in the East Fork Little Blue River watershed (acres).

Wetland Type (system – class)	National Wetland Inventory 1984/5 (acres)	2002 Inventory (acres)
Lacustrine – Aquatic Bottom	1	0
Lacustrine – Unconsolidated Bottom	1,234	1,965
Palustrine – Aquatic Bed	1	28
Palustrine – Emergent	58	42
Palustrine – Forested	162	9
Palustrine – Scrub Shrub	3	0
Palustrine – Unconsolidated Bottom	152	181
Total	1,611	2,225

Table 2. Comparison of wetland inventories according to system and class for the East Fork Little Blue River Watershed.

Rock Creek

At first glance, the amount of wetland loss in this watershed does not appear to be significant (Table 3). However, when comparing the land use change statistics of this watershed it is evident that the amount of wetland loss is near the same percentage of urban gain. The wetlands in this watershed may be at an advantage because most of the wetlands lie along Rock Creek or the Mississippi River. Unless flows are restricted on Rock Creek, or it becomes channelized, the hydrology of these wetlands should be sustained. The same is true of the wetlands along the Mississippi River.

LU/LC Category	1984	2002	Change
Urban	6,626	7,231	+8%
Wetlands	363	320	-12%
Forest	10,525	9,909	-6%
Agriculture	1,412	1,469	-4%
Total	18,926	18,929	

Table 3. Land use/land cover changes in the Rock Creek watershed (acres).

Wetland Type (system – class)	National Wetland Inventory 1984 (acres)	2002 Inventory (acres)
Riverine – Unconsolidated Shore	4	1
Riverine – Unconsolidated Bottom	54	31
Palustrine – Aquatic Bed	0	0
Palustrine – Emergent	13	3
Palustrine – Forested	198	205
Palustrine – Scrub Shrub	22	20
Palustrine – Unconsolidated Bottom	72	60
Total	363	320

Table 4. Comparison of wetland inventories according to system and class for the Rock Creek Watershed.

Water Quality

Several sampling locations did not contain surface water from which to sample during every field visit. There were a total of 18 sampling visits and only one location contained water on each visit (East Fork Little Blue River, Site D-Q). The summary of water quality statistics (Table 5) shows that of the parameters that were sampled, very few were elevated. The site with the fewest samples collected (nine) is site D-U in the East Fork Little Blue River watershed.

Wetland Location		Total Phosphorous (mg/L)	pH	Dissolved Oxygen (mg/L)	Conductivity (ms/cm)	Nitrogen as Nitrate (mg/L)	Nitrogen as Nitrite (mg/L)	Nitrogen as Ammonia (mg/L)	Temperature (C)
East Fork Little Blue River	D-Q	Max = 1.77 Min = 0.00 Mean = 0.23 S _n = 14	Max = 9.04 Min = 7.38 Mean = 7.96 S _n = 15	Max = 18.66 Min = 5.17 Mean = 10.6 S _n = 12	Max = 653 Min = 241 Mean = 471 S _n = 17	Max = 3.0 Min = 0.000 Mean = 1.18 S _n = 17	Max = 2.8 Min = 0.00 Mean = 0.587 S _n = 17	Max = 0.65 Min = 0.00 Mean = 0.23 S _n = 17	Max = 27.3 Min = -1.9 Mean = 18.29 S _n = 18
	D-U	Max = 0.55 Min = 0.00 Mean = 0.18 S _n = 6	Max = 8.21 Min = 7.49 Mean = 7.78 S _n = 9	Max = 12.31 Min = 2.85 Mean = 7.8 S _n = 9	Max = 454 Min = 285 Mean = 396 S _n = 9	Max =2.0 Min = 0.0 Mean = 1.15 S _n = 10	Max = 0.01 Min = 0.000 Mean = 0.007 S _n = 10	Max = 0.46 Min = 0.01 Mean = 0.16 S _n = 10	Max = 51.4 Min = 18.8 Mean = 30.98 S _n = 9
	E-T	Max = 1.5 Min = 0.0 Mean = 0.12 S _n = 11	Max = 8.61 Min = 7.38 Mean = 7.98 S _n = 15	Max = 10.3 Min = 5.1 Mean = 8.03 S _n = 9	Max = 924 Min = 444 Mean = 606 S _n = 15	Max = 2.8 Min = 0.0 Mean = 1.36 S _n = 14	Max = 0.01 Min = 0.00 Mean = 0.003 S _n = 14	Max = 0.27 Min = 0.00 Mean = 0.07 S _n = 14	Max = 9.6 Min = 0.0 Mean = 13.3 S _n = 15
	F-K	Max = 2.58 Min = 0.00 Mean = 0.75 S _n = 9	Max = 8.44 Min = 6.97 Mean = 7.59 S _n = 12	Max = 22.4 Min = 2.54 Mean = 12.29 S _n = 12	Max = 434 Min = 380 Mean = 413 S _n = 12	Max = 1.5 Min = 0.0 Mean = 0.6 S _n = 12	Max = 0.037 Min = 0.000 Mean = 0.008 S _n = 12	Max = 2.14 Min = 0.00 Mean = 0.58 S _n = 12	Max = 13.5 Min = 15.8 Mean = 17.34 S _n = 12
	H-I	Max = 2.75 Min = 0.06 Mean = 0.47 S _n = 7	Max = 8.48 Min = 7.43 Mean = 7.82 S _n = 12	Max = 21.8 Min = 5.52 Mean = 11.8 S _n = 12	Max = 510 Min = 245 Mean = 382 S _n = 12	Max = 1.1 Min = 0.0 Mean = 0.59 S _n = 10	Max = 0.005 Min = 0.001 Mean = 0.002 S _n = 10	Max = 0.42 Min = 0.00 Mean = 0.15 S _n = 10	Max = 26.7 Min = 3.7 Mean = 13.61 S _n = 12
Rock Creek	JJ	Max = 1.75 Min = 0.04 Mean = 0.43 S _n = 10	Max = 8.94 Min = 7.67 Mean = 8.15 S _n = 12	Max = 19.22 Min = 5.8 Mean = 12.64 S _n = 9	Max = 629 Min = 540 Mean = 594 S _n = 12	Max = 1.8 Min = 0.00 Mean = 1.16 S _n = 15	Max = 0.01 Min = 0.00 Mean = 0.008 S _n = 15	Max = 0.96 Min = 0.06 Mean = 0.36 S _n = 15	Max = 24.4 Min = 5.1 Mean = 16.34 S _n = 12

Table 5. Summary of water quality statistics for all locations, 2001-2004.

Soil Quality

Results were compared to the Cleanup Action Levels for Missouri (CALM) listed in Table 6. Concentration levels of the four metals tested are not elevated. When compared to a study of industrial atmospheric pollution of wetland soils at the Indiana Dunes National Lakeshore (Perkins, Filippelli and Souch 2000), the levels at all of the sites sampled in this study are on the low end of the spectrum.

	copper (ppm)	nickel (ppm)	lead (ppm)	zinc (ppm)
MSHS	14.1	13.6	25.9	55.6
East Fork Site D	17.0	20.7	16.8	61.8
East Fork Site E	16.4	22.3	24.5	57.9
East Fork Site F	17.6	21.7	17.2	73.4
East Fork Site H	18.6	23.5	14.7	75.6
CALM ¹	1,100	4,800	260	38,000
Indiana Dunes National Lakeshore ²	17-150	14-42	65-280	95-1700

Table 6. Summary of soil metal analysis for both wetland sites.

¹Cleanup Action Levels for Missouri, residential

²Perkins, Filippelli and Souch 2000. *See References*

Discussion

Land Use/Land Cover Change

The influence of climate on Jackson County should not be overlooked during this study. These aerial photos used to estimate land use/land cover were taken in March 2002, when the region had been experiencing periodic drought. Some areas that are typically wet were not captured by the photography due to the dry conditions; consequently they were not classified as wetlands.

A need exists for an updated wetland inventory. The last wetland inventory for Missouri was the National Wetland Inventory in the early 1980's. Within the last 20 years, regions of the state have undergone intensive urbanization, and flow regulation along major rivers continues to threaten riparian wetlands. The update should be of a smaller scale than the NWI using high resolution remote sensing (i.e. color infrared aerial photography or satellite imagery). An updated and smaller scale inventory would illuminate the extent to which wetlands are being threatened and the source agents of pressure. Since the SWANCC decision (Solid Waste Authority of Northern Cook County vs. U.S. Army Corps of Engineers, Slip Opinion, No. 991178, October Term 2000), isolated wetlands have less protection, and we have little information on how many of these isolated wetlands still exist within Missouri or where they are located. Many state and federal agencies and non-governmental organizations that have an interest in Missouri's environment would benefit from an updated and higher resolution wetland inventory.

Scale of the photography is also an issue that needs to be addressed. The wetland inventory created here should not be compared to the NWI from an accuracy standpoint

due to scale alone. The NWI was created using 1:58,000 scale photography and the March 2002 photos were 1:10,000 scale.

Water Quality

Since there was no previous water quality data collected from these wetlands for comparison, this data will mainly serve as baseline information. A comparison was made to a study by the USGS on remnant wetlands in Missouri (Heimann and Femmer 1998). Of the urban wetlands sampled, water quality results are similar to the remnant wetlands for nitrate, nitrite, ammonia nitrate and total phosphorous. This may be due to sampling only on public land. Both study sites (Fleming Park and Mastodon State Historic Site) are large areas that may be filtering out the pollutants before it reaches the wetland complexes. It would be worthwhile to sample a greater number of wetlands and streams to investigate the benefits of public lands in urban areas with filtering stormwater runoff.

At present, there are no water quality standards for wetlands within the State of Missouri. Even though water quality data can be obtained and published, there are no standards by which to determine acceptable pollution levels. If there are no standards and nutrient levels are high, there is no level by which remediation of those nutrients can be regulated.

A great majority of the wetlands that still exist are in the form of constructed retention ponds and farm ponds. Research should examine what function these artificial wetlands perform within urban systems. Reality is such that constructed wetlands may be better than no wetlands at all; they may provide water quality improvement and wildlife habitat. These constructed wetlands may help remove excess nutrients from the water system. Research shows that restored wetlands have improved water quality in agricultural and urban watersheds (Baker, Wiley and Seelbach 2001; Gove, Edwards and Conquest 2001). Small (1-5 acres in size), restored and constructed wetlands in an urban watershed setting may play a significant role in maintaining or improving water quality at the landscape scale. Therefore, further research should also focus on the role that these types of wetlands play in the retention of nutrients, such as nitrogen and phosphorous, that is associated with urban land uses.

Soil Sampling

Similar to water quality, no background soil quality data existed to which current data could be compared. However in comparison to CALM standards, it appears as if there is very little soil contamination of zinc, lead, copper and nickel in the wetlands sampled. Furthermore, the levels detected within Mastodon SHS and the locations along the East Fork are either at the low end of the scale or not at all as those levels found at the Indiana Dunes (Perkins, Filipelli and Souch 2000). The discrepancy may be due to the lack of industrial air pollution infiltrating the wetland sampling sites as was attributed to the pollution levels found at the Indiana Dunes. Data collected during the course of this project will be best utilized during future research and/or monitoring.

Glossary

Palustrine	Includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5%. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: 1) area less than 8 ha (20 acres), 2) active wave-formed or bedrock shoreline features lacking; 3) water depth in the deepest part of basin less than 2 meters at low water; and 4) salinity due to ocean-derived salts less than 0.5% (Cowardin et al 1979)
Lacustrine	Includes wetlands and deepwater habitats with all of the following characteristics: 1) situated in a topographic depression of dammed river channel; 2) lacking trees, shrubs, persistent emergents, emergent mosses and lichens with greater than 30% areal coverage; and 3) total area exceeds 8 ha (20 acres). Lacustrine waters may be tidal or non-tidal, but ocean-derived salinity is always less than 0.5% (Cowardin et al 1979)
Riparian Wetland	Located along rivers and streams that are occasionally flooded by those bodies of water, but typically dry otherwise (Mitsch and Gosselink 1986)

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